FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: R.35482

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR): 10/088897

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE 00/03393	28 September 2000	29 September 1999

TITLE OF INVENTION

INJECTOR FOR A FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES WITH AN INTEGRATED SYSTEM PRESSURE SUPPLY

APPLICANT(S) FOR DO/EO/US

Patrick MATTES

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☒ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☒ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☒ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Transmittal Sheets in duplicate w/ fees charged to Dep. Acct. 07-2100 - Copy of German Text Appl. w/3 sheets drawings- Transl. of German Text Appl. w/3 sheets drawings- Copy of German Text Amended Pages- Transl. of German Text Amended Pages- Preliminary Amendment- Letter to Official Draftsman w/markings in red- Copies of PCT/RO/101, PCT/ISA/210 and 220, and PCT/IPEA/401,409, and 416- Executed Declaration and Assignment (NOT ENCLOSED)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/088897	PCT/DE 00/03393	R.35482

24. The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$130.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	19 - 20 =	0	x $18.00	**$0.00**	
Independent claims	- 3 =	0	x $84.00	**$0.00**	
Multiple Dependent Claims (**check if applicable**).			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,020.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**	
SUBTOTAL =				**$1,020.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$1,020.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (**check if applicable**). ☐				**$0.00**	
TOTAL FEES ENCLOSED =				**$1,020.00**	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of _____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. **07-2100** in the amount of **$1,020.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **07-2100** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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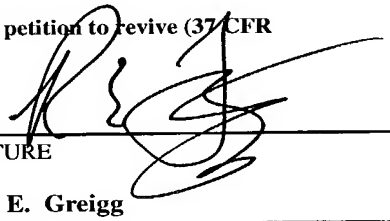

SIGNATURE

Ronald E. Greigg
NAME

31,517
REGISTRATION NUMBER

25 March 2002
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Patrick MATTES

Based on PCT/DE 00/03393

For: INJECTOR FOR A FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES WITH AN INTEGRATED SYSTEM PRESSURE SUPPLY

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-referenced application as follows:

IN THE SPECIFICATION

Page 1, Between the title and paragraph [0001] insert the following:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. application of PCT/DE 00/03393, filed on September 28, 2000.

[0000.6] BACKGROUND OF THE INVENTION

Replace paragraph [0001] with the following rewritten paragraph:

[0001] Field Of The Invention

Between paragraphs [0001] and [0002] insert the following:

[0002.5] Description Of The Prior Art

Page 2, Between paragraphs [0005] and [0006] insert the following:

[0005.4] From Fig. 13 of German Patent Disclosure DE 39 36 619, an injection nozzle is known that has a high-pressure connection; the high-pressure connection communicates hydraulically with an inflow conduit via a bore, and a conduit to the system pressure supply branches off from the bore, and a bush with a longitudinal bore is disposed in the bore. In this injection nozzle, the longitudinal bore is embodied as an inflow conduit for a control chamber. The inflow conduit is supplied directly via the bore with fuel from the high-pressure connection. With this arrangement, it is not possible to furnish a simple, operational reliable system pressure supply for an injector.

[0005.6] Nor is this possible with the prior art, German Published, Nonexamined Patent Application DE-OS 28 54 921 that is cited in DE 39 36 619.

[0005.8] OBJECTS AND SUMMARY OF THE INVENTION

Between paragraphs [0006] and [0007] insert the following:

[0006.5] According to the invention, in an injector for a fuel injection system for internal combustion engines, having a high-pressure connection, wherein the high-pressure connection communicates hydraulically with an inflow conduit via a bore, wherein a conduit to the system pressure supply branches off from the bore, and wherein a bush with a longitudinal bore is disposed in the bore, this object is attained in that the inflow conduit is supplied with fuel from the high-pressure connection through the longitudinal bore of the bush, and that the fuel inflow to the conduit is effected outside the bush.

Page 3, Replace paragraph [0010] with the following rewritten paragraph:

[0010] In one embodiment of the invention, it is provided that on one end of the bush, the longitudinal bore, bush and bore are sealed off from one another, and that in the region of this end, the conduit to the system pressure supply branches off from the bore, so that the fuel that is under high pressure from the high-pressure connection cannot flow into the conduit to the system pressure supply in a short circuit, bypassing the annular gap between the bore and the bush.

Page 4, Between paragraphs [0015] and [0016] insert the following:

[0015.5] BRIEF DESCRIPTION OF THE DRAWINGS

Replace paragraph [0016] with the following rewritten paragraph:

[0016] Further advantages and advantageous features of the invention can be learned from the following detailed description, taken with the drawings, in which:

Between paragraphs [0020] and [0021] insert the following:

[0020.5] DESCRIPTION OF THE PREFERRED EMBODIMENTS

Replace paragraph [0021] with the following rewritten paragraph:

[0021] Fig. 1 shows an injector of the invention, with a housing 1 on whose upper end is a high-pressure connection 3. In the installed state of the injector, a high-pressure line, not shown, opens into this high-pressure connection 3 and supplies the injector with fuel, which is at high pressure P_{cr}, from the common rail, also not shown, or the injection pump, likewise not shown. The high-pressure connection 3 has a bore 5. A rod filter 7 is disposed in the upper part of the bore and prevents contaminants from reaching the injector. Below the rod filter 7, a bush 9 is disposed in the bore 5. The bush 9 has a longitudinal bore 11. Through the longitudinal bore 11, a hydraulic communication is established between the high-pressure line, not shown, and an inflow conduit 13, which supplies the control valve, not shown, and the injection nozzle with fuel that is at high pressure. A conduit 15 to the system pressure supply branches off in the lower region of the bore 5.

Page 7, Replace paragraph [0028] with the following rewritten paragraph:

[0028] In Fig. 3, the bush 9 is shown deformed. Neither the deformation of the bush 9 nor the size of the annular gap 19 is shown to scale but instead is shown only qualitatively. The pressure course in the annular gap is shown qualitatively in the P/X graph in Fig. 3. In this graph, "X" is the location coordinate extending in the direction of the longitudinal axis of the bore 5.

Delete paragraph [0031]:

After paragraph [0031] insert the following new paragraph:

[0032] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 8, Line 1, delete “Claims” and insert --“I Claim”--.

IN THE CLAIMS

Please cancel claims 1-10 and add new claims 11-29.

11. An injector for a fuel injection system for internal combustion engines, comprising

a high-pressure connection (3), wherein the high-pressure connection (3) communicates hydraulically with an inflow conduit (13) via a bore (5),

a conduit (15) to the system pressure supply branching off from the bore (5), and

a bush (9) with a longitudinal bore (11) disposed in the bore (5),

the inflow conduit (13) being supplied with fuel from the high-pressure connection (3) through the longitudinal bore (11) of the bush (9), and

the fuel inflow to the conduit (15) being effected outside the bush (9).

12. The injector of claim 11 wherein there is a play, in particular of 6 to 8 µm, between the bore (5) and the bush (9).

13. The injector of claim 11 wherein on one end of the bush (9), the longitudinal bore (11), bush (9) and bore (5) are sealed off from one another, and that in the region of this end, the conduit (15) to the system pressure supply branches off from the bore (5).

14. The injector of claim 12 wherein on one end of the bush (9), the longitudinal bore (11), bush (9) and bore (5) are sealed off from one another, and that in the region of this end, the conduit (15) to the system pressure supply branches off from the bore (5).

15. The injector of claim 11 wherein both ends of the bush (9) are approximately equally spaced from the branching point of the conduit (15).

16. The injector of claim 12 wherein both ends of the bush (9) are approximately equally spaced from the branching point of the conduit (15).

17. The injector of claim 11 wherein the injector further comprising a leak fuel return line.

18. The injector of claim 17 wherein the leak fuel return line communicates with the conduit (15) to the system pressure supply.

19. The injector of claim 12 wherein the leak fuel return line communicates with the conduit (15) to the system pressure supply.

20. The injector of claim 13 wherein the leak fuel return line communicates with the conduit (15) to the system pressure supply.

21. The injector of claim 15 wherein the leak fuel return line communicates with the conduit (15) to the system pressure supply.

22. The injector of claim 17 further comprising a pressure holding valve (18) disposed in the leak fuel return line.

23. The injector of claim 18 further comprising a pressure holding valve (18) disposed in the leak fuel return line.

24. The injector of claim 11 wherein the pressure holding valve (18) maintains a minimum pressure, in particular of 15 to 20 bar, in the conduit (15) to the system pressure supply.

25. The injector of claim 13 wherein the pressure holding valve (18) maintains a minimum pressure, in particular of 15 to 20 bar, in the conduit (15) to the system pressure supply.

26. The injector of claim 15 wherein the pressure holding valve (18) maintains a minimum pressure, in particular of 15 to 20 bar, in the conduit (15) to the system pressure supply.

27. The injector of claim 17 wherein the pressure holding valve (18) maintains a minimum pressure, in particular of 15 to 20 bar, in the conduit (15) to the system pressure supply.

28. The injector of claim 11 wherein the injector has a piezoelectric actuator.

29. The injector of claim 28 characterized in that in the injector between the piezoelectric actuator and a control valve, a hydraulic booster is present, which is filled via the conduit (15) to the system pressure supply.

IN THE ABSTRACT

Please substitute the attached rewritten Abstract of the Disclosure for the Abstract as originally filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

An injector for a fuel injection system for internal combustion engines is proposed, whose system pressure supply is integrated with the injector. This results in a simple design with at the same time a low requirement for driving capacity on the part of the high-pressure pump for supplying system pressure.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Page 1, Paragraph [0001] has been amended as follows:

[0001] ~~Prior Art~~ Field Of The Invention

Page 3, Paragraph [0010] has been amended as follows:

[0010] In ~~a supplement to~~ one embodiment of the invention, it is provided that on one end of the bush, the longitudinal bore, bush and bore are sealed off from one another, and that in the region of this end, the conduit to the system pressure supply branches off from the bore, so that the fuel that is under high pressure from the high-pressure connection cannot flow into the conduit to the system pressure supply in a short circuit, bypassing the annular gap between the bore and the bush.

Page 4, Paragraph [0016] has been amended as follows:

[0016] Further advantages and advantageous features of the invention can be learned from the following ~~drawing, description and claims. Shown are~~ detailed description, taken with the drawings, in which:

Paragraph [0021] has been amended as follows:

[0021] Fig. 1 shows an injector of the invention, with a housing 1 on whose upper end is a high-pressure connection 3. In the installed state of the injector, a high-pressure line, not shown, opens into this high-pressure connection 3 and supplies the injector with fuel, which is at high pressure P_{cr}, from the common rail, also not shown, or the injection pump, likewise not shown. The high-pressure connection 3 has a bore 5. A rod filter 7 is disposed in the upper part of the bore and prevents contaminants from

reaching the injector. Below the rod filter 7, a bush 9 is disposed in the bore 5. The bush 9 has a longitudinal bore 11. Through the longitudinal bore 11, a hydraulic communication is established between the high-pressure line, not shown, and an inflow conduit 13, which supplies the control valve, not shown, and the injection nozzle with fuel that is at high pressure. A conduit 15 to the system pressure supply branches off in the lower region of the bore 5.

Page 7, Paragraph [0028] has been amended as follows:

[0028] In Fig. 3, the bush 9 is shown deformed. Neither the deformation of the bush 9 nor the size of the annular gap 19 is shown to scale but instead is shown only qualitatively. The pressure course in the annular gap is shown qualitatively in the P/X graph in Fig. 3. In this graph, "X" is the location coordinate extending in the direction of the longitudinal axis of the bore ~~(5)~~ 5.

Page 10, Abstract

~~Abstract~~ ABSTRACT OF THE DISCLOSURE

An injector for a fuel injection system for internal combustion engines is proposed, whose system pressure supply is integrated with the injector. This results in a simple design with at the same time a low requirement for driving capacity on the part of the high-pressure pump for supplying system pressure.

~~(Fig. 1)~~

10/088897

JC13 Rec'd PCT/PTO 25 MAR 2002

SUBMISSION OF PROPOSED DRAWING AMENDMENT FOR APPROVAL BY EXAMINER (37 CFR 1.121(a)(3)(ii) or 37 CFR 1.121(b)(3)(ii))	Docket No. R.35482

In Re Application Of: **Patrick MATTES**

Serial No.	Filing Date	Examiner	Art Unit

Invention: **INJECTOR FOR A FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES WITH AN INTEGRATED SYSTEM PRESSURE SUPPLY**

Address to:
Assistant Commissioner for Patents
Washington, D.C. 20231

Attached please find:

(check applicable items)

☐ a sketch in permanent ink

☒ a copy of the original drawing(s) with red ink FIGURE 2

showing proposed changes to the drawing(s) in this application for which the approval of the examiner is requested.

Signature

Ronald E. Greigg
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Customer No. 02119

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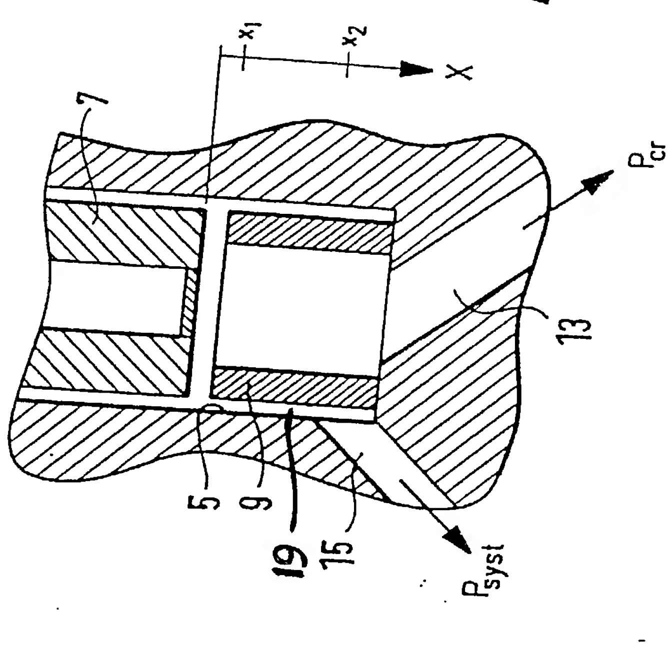
Dated: **25 MARCH 2002**

I certify that this document and fee is being deposited on with the U.S. Postal Service as first class mail under 37 C.F.R. 1.8 and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Signature of Person Mailing Correspondence

Typed or Printed Name of Person Mailing Correspondence



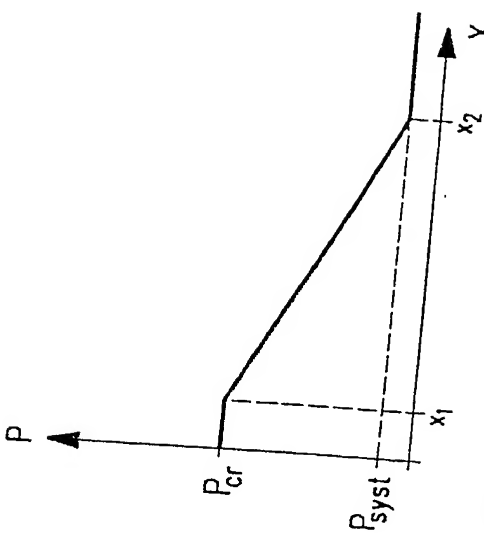


Fig. 2

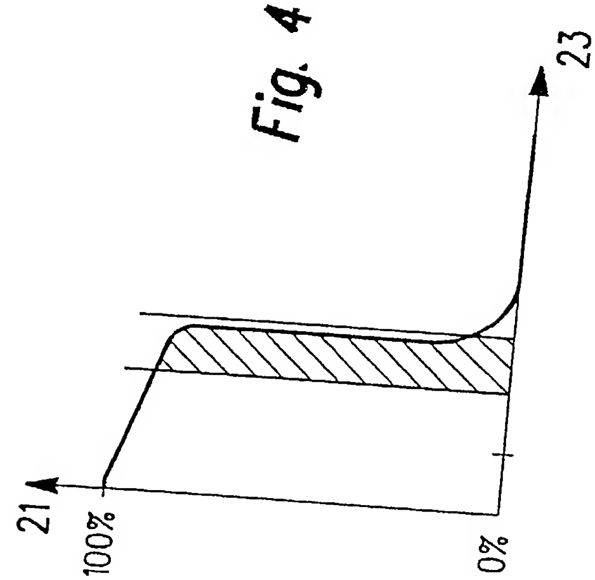


Fig. 4

INJECTOR FOR A FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES WITH AN INTEGRATED SYSTEM PRESSURE SUPPLY

[0001] Prior Art

[0002] The invention is based on an injector for a fuel injection system for internal combustion engines, having a high-pressure connection, the high-pressure connection communicating with an inflow conduit via a bore.

[0003] Some injectors, because of their design, require a system pressure that is markedly less than the pressure P_{cr} in the common rail, that is, the injection pressure. For instance, in injectors with a piezoelectric actuator, to lengthen the stroke of the piezoelectric actuator and compensate for the temperature-dictated length, a hydraulic booster is used. To fill this hydraulic booster, a system pressure of up to 20 bar must be present in the injector upon starting and during operation. Furnishing the requisite quantity of leak fuel is accomplished either by internal leaks in the injector or from outside.

[0004] Since in some embodiments of injectors no internal leaks occur, until now in these embodiments the pressure has had to be furnished from outside via high-pressure lines. Such an embodiment, because of the high pressure level and the high operating temperatures is expensive to produce and is vulnerable to malfunction.

[0005] Another disadvantage of the system pressure supply according to the prior art is that the system pressure is adjusted by means of throttles with a constant flow rate. This kind of throttling requires a high driving capacity on the part of the high-pressure pump and reduces the efficiency of the engine accordingly.

[0006] It is the object of the invention to furnish an injector with a piezoelectric actuator whose system pressure supply is simple, economical and operationally reliable. Moreover, the capacity requirement of the high-pressure pump for the system pressure supply should be low.

[0007] This object is attained according to the invention by an injector for a fuel injection system for internal combustion engines, having a high-pressure connection, the high-pressure connection communicating hydraulically with an inflow conduit via a bore, and a conduit to the system pressure supply branches off from the bore, and a bush with a longitudinal bore is disposed in the bore.

[0008] This injector has the advantage that in the annular gap between the bush and the bore, the high pressure from the high-pressure connection is reduced so far that at the point where the conduit to the system pressure supply branches off from the bore, essentially only the requisite system pressure now prevails. Thus the system pressure supply is integrated with the injector, so that expensive external system pressure supply lines that are vulnerable to malfunction can be dispensed with. Moreover, the fuel flow into the conduit to the system pressure supply decreases as the pressure in the high-pressure connection increases, so that the requirement for driving capacity on the part of the high-pressure pump for the system pressure supply is low. Moreover, simple hoses can be used to remove the leak fuel, since the leak fuel is removed without pressure.

[0009] In one embodiment of the invention, there is a play, in particular of 6 to 8 µm, between the bore and the bush, so that an annular gap of defined thickness (3 to 4 µm) is formed between the bore and the bush, in which gap the fuel flowing from the high-pressure connection to the conduit to the system pressure supply reduces its pressure so far that the required pressure, for instance of 20 bar, is present in the conduit to the system pressure supply.

[0010] In a supplement to the invention, it is provided that on one end of the bush, the longitudinal bore, bush and bore are sealed off from one another, and that in the region of this end, the conduit to the system pressure supply branches off from the bore, so that the fuel that is under high pressure from the high-pressure connection cannot flow into the conduit to the system pressure supply in a short circuit, bypassing the annular gap between the bore and the bush.

[0011] A further variant provides that both ends of the bush are approximately equally far away from the branching point of the conduit, so that in every case, the fuel under high pressure from the high-pressure connection must flow through an annular gap before it reaches the conduit to the system pressure supply. Thus it is also possible to dispense with a seal on one end of the bush between the bush and the bore. This makes this embodiment especially operationally reliable.

[0012] Further supplements to the invention provide that the injector has a leak fuel return line and that the leak fuel return line communicates with the conduit to the system pressure supply, so that excess fuel, which has for instance flowed from the high-pressure connection into the conduit to the system pressure supply, can be removed from the injector, and the pressure in the conduit to the system pressure supply and in the hydraulic booster does not increase excessively.

[0013] In other features of the invention, a pressure holding valve is disposed in the leak fuel return line, which maintains a minimum pressure, in particular of 15 to 20 bar, so that the requisite system pressure is always present.

[0014] A variant of the invention provides that the injector has a piezoelectric actuator, so that in injectors of this design as well, the advantages of the system pressure supply according to the invention can be utilized.

[0015] In a supplement to the invention, between the piezoelectric actuator and a control valve there is a hydraulic booster, which is filled via the conduit to the system pressure supply, so that the filling is accomplished simply and reliably.

[0016] Further advantages and advantageous features of the invention can be learned from the following drawing, description and claims. Shown are:

[0017] Fig. 1, a first embodiment of an injector of the invention in longitudinal section;

[0018] Fig. 2, a detail marked X of the injector of Fig. 1;

[0019] Fig. 3, a detail of a second embodiment of an injector of the invention in longitudinal section; and

[0020] Fig. 4, a qualitative graph of flow rate and pressure for a system pressure supply of the invention for an injector.

[0021] Fig. 1 shows an injector of the invention, with a housing 1 on whose upper end is a high-pressure connection 3. In the installed state of the injector, a high-pressure line, not shown, opens into this high-pressure connection 3 and supplies the injector with fuel, which is at high pressure P_{cr}, from the common rail, also not shown, or the

injection pump, likewise not shown. The high-pressure connection 3 has a bore 5. A rod filter 7 is disposed in the upper part of the bore and prevents contaminants from reaching the injector. Below the rod filter 7, a bush 9 is disposed in the bore 5. The bush 9 has a longitudinal bore 11. Through the longitudinal bore 11, a hydraulic communication is between the high-pressure line, not shown, and an inflow conduit 13, which supplies the control valve, not shown, and the injection nozzle with fuel that is at high pressure. A conduit 15 to the system pressure supply branches off in the lower region of the bore 5.

[0022] The bush 9 is joined sealingly at its lower face end to the bottom 17 of the bore 5. This means that the fuel that is under high pressure in the high-pressure connection 3 can reach the conduit 15 to the system pressure supply only through the annular gap between the bush 9 and the bore 5. In the process, a pressure reduction takes place, so that by the time the fuel reaches the conduit 15 to the system pressure supply, it has only the requisite system pressure P_{syst} of about 15 to 20 bar.

[0023] To prevent the flow rate in the conduit 15 to the system pressure supply from rising as well with increasing pressure P_{cr} in the high-pressure connection 3, the bush 9 is designed such that it is pressed in the direction of the bore 5 as a result of the pressure difference between the longitudinal bore 11 and the annular gap between the bush 9 and the bore 5. As a result, the annular gap between the bush 9 and the bore 5 is reduced in size, and the consequence is an increased reduction of pressure in the annular gap.

[0024] Above a pressure that is dependent on the design of the bush 9 and housing 1 as well as on the pressure in the high-pressure connection 3, the bush 9 is pressed against the bore 5, so that no further fuel from the high-pressure connection 3 can enter the conduit 15 to the system pressure supply. This prevents impermissibly high pressures from prevailing in the conduit 15 to the system pressure supply and in the

hydraulic booster connected to it. The fuel flowing into the conduit 15 to the system pressure supply is diverted into the leak fuel return line, not shown, via a pressure holding valve 18. The pressure holding valve 18 can for instance be a spring-loaded ball valve, which is adjusted such that if the system pressure P_{syst} of about 15 to 20 bar in the conduit 15 to the system pressure supply is exceeded, it opens and thus brings about a reduction in the prevailing pressure level in the conduit 15.

[0025] In Fig. 2, the detail marked X in Fig. 1 is shown. The bore 5, rod filter 7, inflow conduit 13, conduit 15 to the system pressure supply and the bush 9 can be seen. In Fig. 2, the bush 9 is not deformed by the pressure difference between the longitudinal bore 11 and an annular gap 19.

[0026] As soon as fuel flows through the annular gap 19, its pressure decreases continuously, in accordance with the P/X graph shown next to the bush 9, so that an increasing pressure difference ensues between the fuel located in the longitudinal bore 11 and that located in the annular gap 19. The consequence of this pressure difference is a deformation, not shown in Fig. 2, of the bush 9. As soon as the pressure difference between the fuel in the longitudinal bore 11 and in the annular gap 19 exceeds a certain amount, the bush 9 is pressed against the bore 5. This breaks the hydraulic communication between the high-pressure connection 3 and the conduit 15.

[0027] In Fig. 3, a detail of a second embodiment of an injector of the invention is shown. In this embodiment, the branching point of the conduit 15 to the system pressure supply is equally far away from both ends of the bush 9. As a result, the sealing between the bore 5 and the longitudinal bore 11 on one end of the bush 9 can be omitted, since the fuel must in every case flow through the annular gap 19 before it reaches the conduit 15.

[0028] In Fig. 3, the bush 9 is shown deformed. Neither the deformation of the bush 9 nor the size of the annular gap 19 is shown to scale but instead is shown only qualitatively. The pressure course in the annular gap is shown qualitatively in the P/X graph in Fig. 3. In this graph, "X" is the location coordinate extending in the direction of the longitudinal axis of the bore (5).

[0029] As the pressure P_{syst} continues to rise, the deformation of the bush 9 becomes so great that there is no longer any annular gap in the region of the branching point of the conduit 15; that is, the fuel can no longer flow into the conduit 15.

[0030] In Fig. 4, the relationship between the fuel flow rate 21 in the annular gap 19 and the pressure 23 in the high-pressure connection 3 is shown qualitatively. From this graph it becomes clear that with increasing pressure 23 in the high-pressure connection 3, the fuel flow rate 21 through the annular gap 19 decreases, until it becomes zero when a certain pressure is reached.

[0031] All the characteristics described and shown in the description, the following claims and the drawing can be essential to the invention both individually and in arbitrary combination with one another.

Claims

1. An injector for a fuel injection system for internal combustion engines, having a high-pressure connection (3), wherein the high-pressure connection (3) communicates hydraulically with an inflow conduit (13) via a bore (5), characterized in that a conduit (15) to the system pressure supply branches off from the bore (5), and that a bush (9) with a longitudinal bore (11) is disposed in the bore (5).

2. The injector of claim 1, characterized in that there is a play, in particular of 6 to 8 µm, between the bore (5) and the bush (9).

3. The injector of claim 1 or 2, characterized in that on one end of the bush (9), the longitudinal bore (11), bush (9) and bore (5) are sealed off from one another, and that in the region of this end, the conduit (15) to the system pressure supply branches off from the bore (5).

4. The injector of claim 1 or 2, characterized in that both ends of the bush (9) are approximately equally far away from the branching point of the conduit (15).

5. The injector of one of the foregoing claims, characterized in that the injector has a leak fuel return line.

6. The injector of claim 5, characterized in that the leak fuel return line communicates with the conduit (15) to the system pressure supply.

7. The injector of claim 5 or 6, characterized in that a pressure holding valve (18) is disposed in the leak fuel return line.

8. The injector of one of the foregoing claims, characterized in that the pressure holding valve (18) maintains a minimum pressure, in particular of 15 to 20 bar, in the conduit (15) to the system pressure supply.

9. The injector of one of the foregoing claims, characterized in that the injector has a piezoelectric actuator.

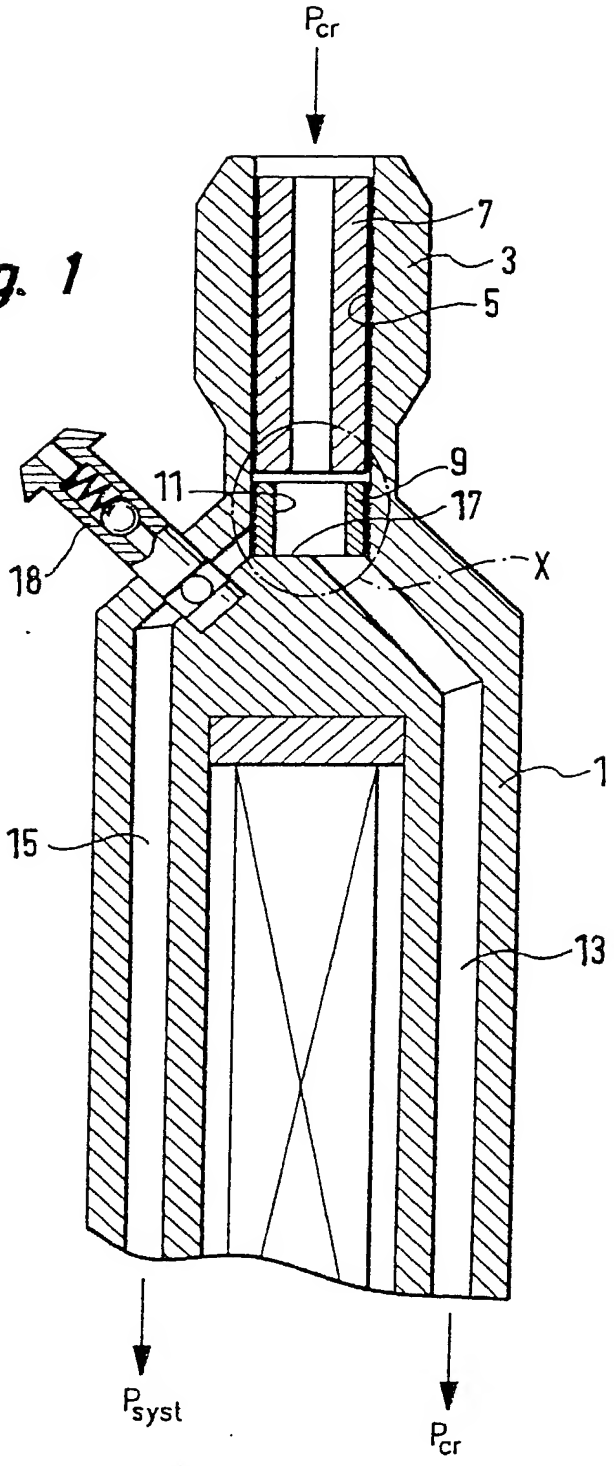
10. The injector of claim 9, characterized in that the injector between the piezoelectric actuator and a control valve, a hydraulic booster is present, which is filled via the conduit (15) to the system pressure supply.

Abstract

An injector for a fuel injection system for internal combustion engines is proposed, whose system pressure supply is integrated with the injector. This results in a simple design with at the same time a low requirement for driving capacity on the part of the high-pressure pump for supplying system pressure.

(Fig. 1)

Fig. 1



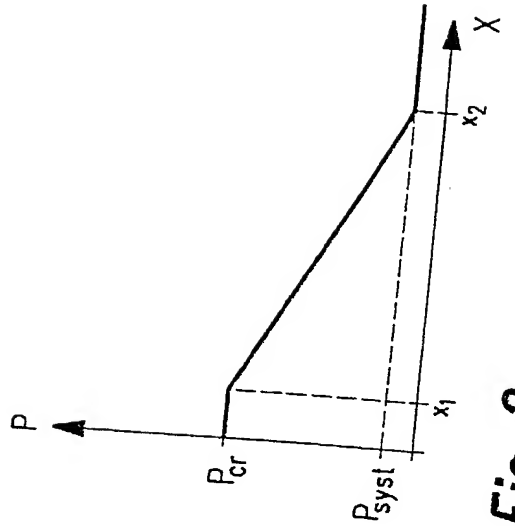
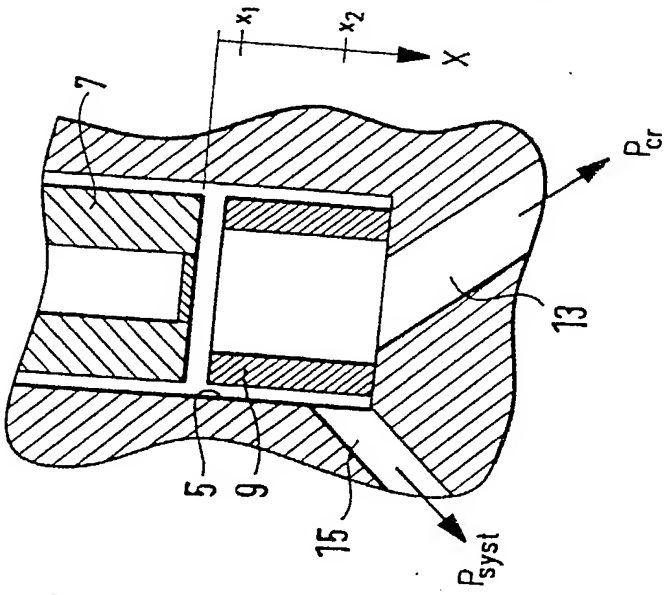


Fig. 2



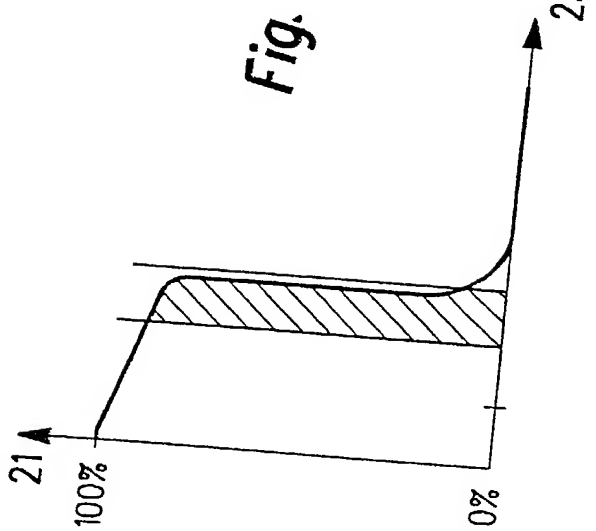


Fig. 4

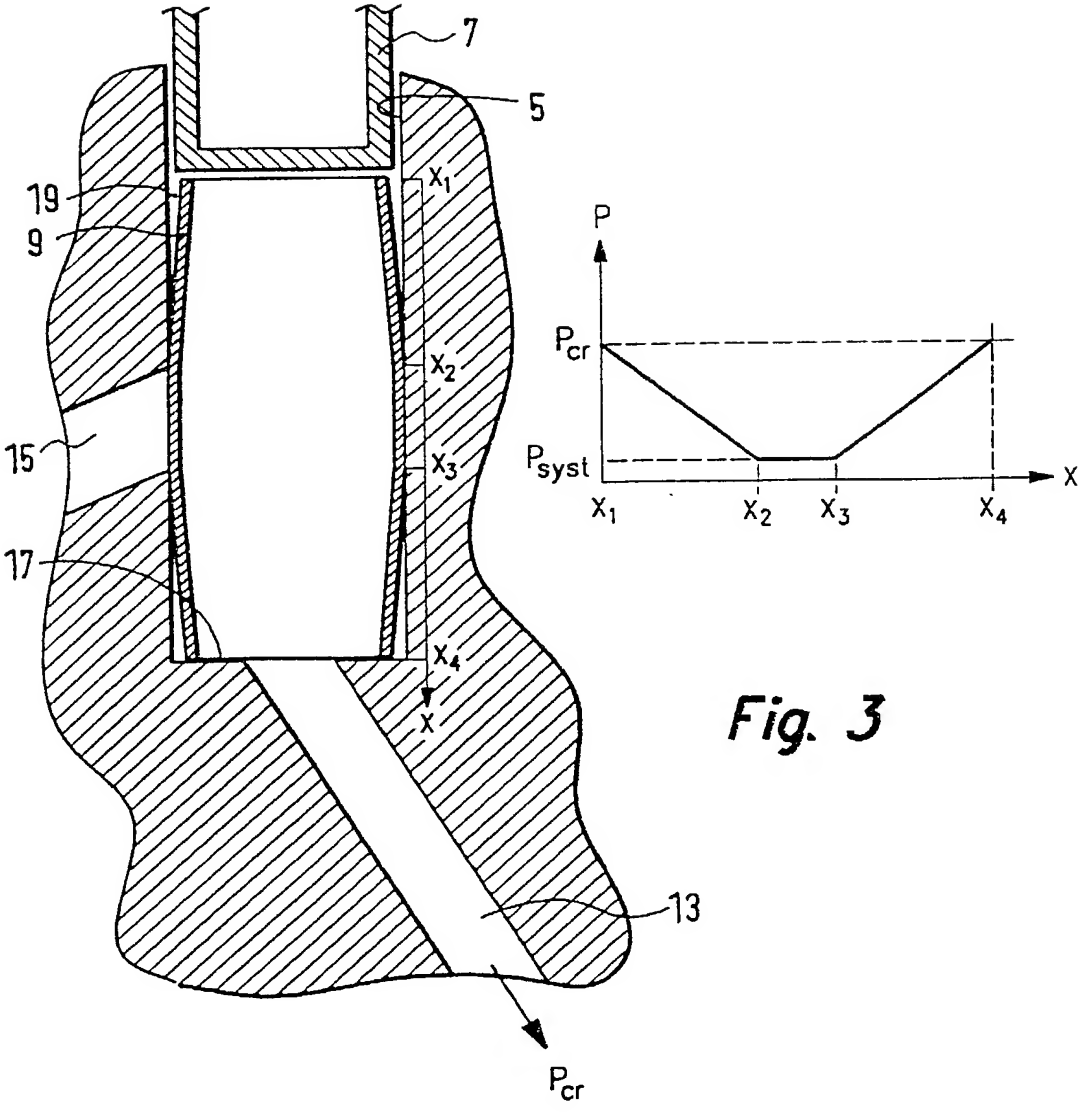


Fig. 3

Docket No.
R.35482

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

INJECTOR FOR A FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES WITH AN INTEGRATED SYSTEM PRESSURE SUPPLY

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 28 SEPTEMBER 2000 as United States Application No. or PCT International Application Number PCT/DE 00/03393

and was amended on ______________________

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed
1 99 46 612.2	GERMANY	29 SEPTEMBER 1999	☒
			☐
			☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Citizenship
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